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THE CROMWELL CURRENT

U. S. NAVY WEATHER RESEARCH FACILITY
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FOREWORD

This report was prepared under Task 36, "Oceanographic Forecasting Techniques," and although short, it is considered important enough to be distributed to naval activities interested in meteorology and/or oceanography. Its purpose is to disseminate information, more widely, on an important discovery in the field of physical oceanography; i.e., the Cromwell Current and its Atlantic counterpart. The contents of this report (based largely on reference [1]) have not been previously available in sources readily accessible to the Navy meteorologist.

Lt. John H. Powell, USN, assembled this information for publication. It was edited by Mr. John M. Mercer.

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1. INTRODUCTION

The Cromwell Current, or Pacific Equatorial Undercurrent, was discovered in 1951. Prior to that time none of the ocean current models portrayed or even hinted at a subsurface current in the equatorial Pacific.

2. HISTORICAL BACKGROUND

Prior to 1952 the known currents of the equatorial Pacific were as depicted by the small solid arrows in figure 2.1. The North Equatorial Current, remaining entirely in the Northern Hemisphere, flows in a westerly direction and normally lies between 10° N. and 15° N. The South Equatorial Current spans the Equator and also flows to the west. Between these two westerly currents is the Equatorial Counter Current, which is normally found between 3° N. and 10° N. and flows to the east.

In the fall of 1951 and spring of 1952, tuna boats from Hawaii fishing at the Equator noticed an unusual drift in which the floats on the long tuna lines drifted to the east while the boats drifted to the west.

In the fall of 1952 an expedition under the leadership of Townsend Cromwell investigated this subsurface current by comparing deep drag drifts with surface drifts. The result of this investigation indicated that a subsurface easterly current existed within 2° of the Equator but was not present further away. Later expeditions checked at various points to determine the longitudinal extent of the current.

In the spring of 1958 the "Dolphin" expedition investigated the

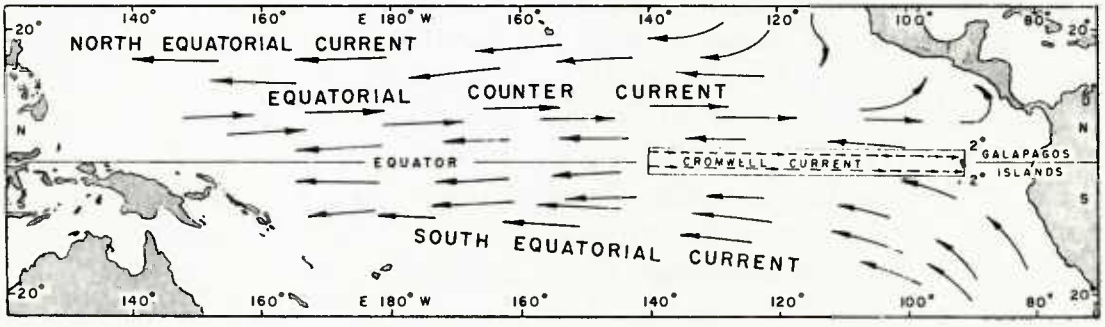

Figure 2.1. Currents of the Equatorial Pacific.

Cromwell Current to determine the dimensions, velocity, and fluctuations of the current and its relationship to the distribution of such properties as salinity, oxygen, phosphate, and temperature. Observations were made from 140° W. to 90° W. These observations consisted of cross section transits across the Equator and single measurements along the Equator. The observations were made with reference to both anchored buoys and deep drogue (sea anchor) parachute type buoys.

3. PHYSICAL CHARACTERISTICS

The Cromwell Current is a narrow, swift current centered on the Equator and apparently extending in width from 2° N. to 2° S., figure 2.1 (dashed arrows). At the Equator the easterly flow appears at the approximate depth of 20 meters, reaches a maximum speed of 2 to 2.5 knots at approximately 100 meters, and finally disappears at roughly 250 meters; figure 3.1. The cross section, in reality, has more of a thin, ribbon-like configuration than the jet-like appearance shown in figure 3.1.

The Cromwell Current was found to extend from 140° W. to 92° W. To the east of the Galapago Islands (92° W.) there was no trace of it. The Galapagos apparently either disrupted the flow or caused it to turn to the north or south. Isolated investigations west of 140° W. have been made to determine the westward extent of the Cromwell Current. These observations have been scattered and varied; consequently until further investigations are made, the positive existence of the current further west cannot be determined.

In the vicinity of the Cromwell Current the chemical characteristics of the upper ocean layers change as the Equator is approached. Both north and south of the Equator a strong thermocline (a vertical transition zone between two layers, marked by a strong thermal gradient) at a depth of 10 to 100 meters is normal in the tropical eastern Pacific. Above the thermocline the water temperature ranges from 25° C. to 28° C. and is nearly constant with depth, indicating vertical mixing. Below the thermocline the water temperature is 10° C. to 12° C. In the transition zone between these two layers the temperature changes rapidly with depth, decreasing as much as 10° C. in 25 meters.

At about 2° N. and 2° S. this typical temperature structure is not as well marked as it is farther north and south, and at the Equator the temperature structure is quite different. Here the surface temperature

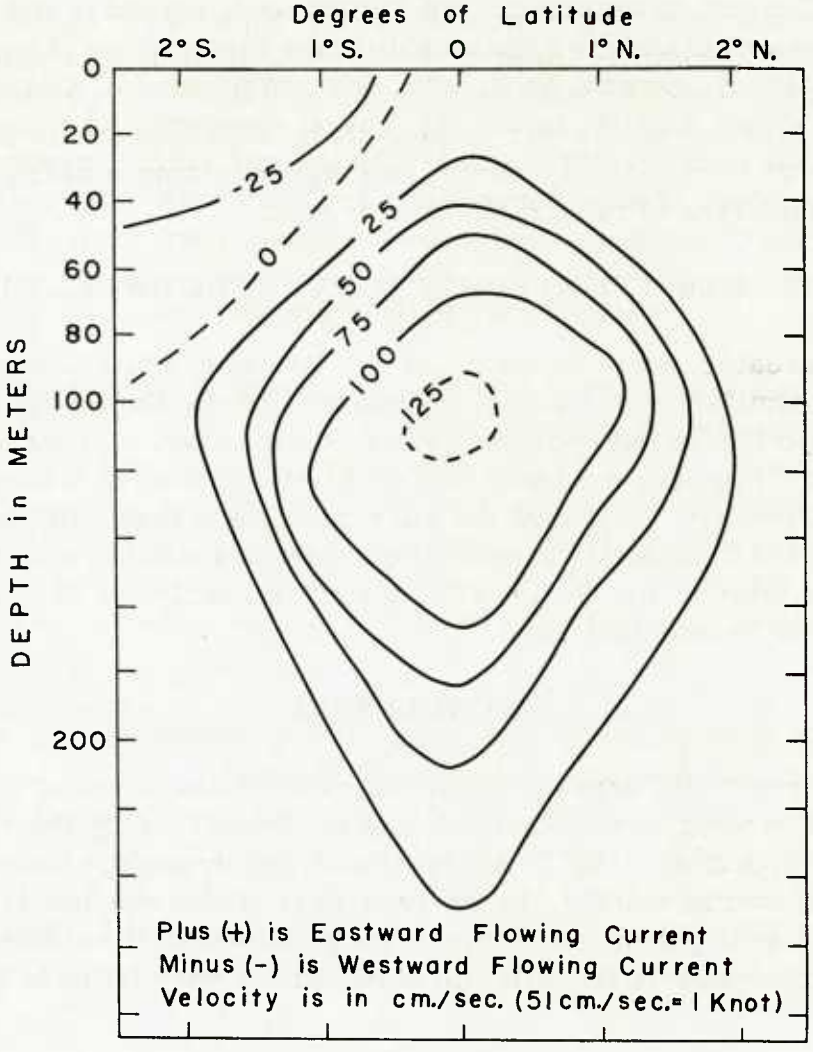

Figure 3.1. Cross Section of the Cromwell Current.

is up to 2° C. cooler than at 4° N. or 4° S., and the thermocline is much thicker and much weaker, indicating that strong vertical mixing occurs to greater depths.

One result of this is that sonar performance will normally be quite different at the Equator than at short distances from it. Sound shadow zones, i.e., zones in which the energy from a submerged sound transmitter is effectively excluded by refractive index gradients, will be less sharply defined at the Equator; consequently, search sonar should be more effective at the Equator where the Cromwell Current is found than in adjacent waters.

In addition the oxygen content at the Equator, in the vicinity of the Cromwell Current, is lower at the surface than it is to either side, but the oxygen content below the surface and down to 300 meters was found to be higher. Water low in phosphate also appears to be mixed downward. The zone of temperature and oxygen mixing appears to agree with the boundaries of the Cromwell Current.

4. THE ATLANTIC COUNTERPART OF THE CROMWELL CURRENT

The great current systems of the Atlantic and Pacific Oceans have many similarities. With the discovery of the Cromwell Current in the Pacific it was only natural to ask if a similar current exists in the Atlantic. Positive evidence of the existence of such a current has been found recently. Although the current has not been studied as extensively as the Cromwell Current, the evidence available indicates that it is very similar to the Cromwell Current in nearly all respects. Its length has not been established.

5. CONCLUSION

The Cromwell Current is a major current and in mass transport is one of the largest in the Pacific being exceeded only by the Kuroshio Current. It appears to be in approximate geostrophic balance. The current is known to exist in the eastern part of the equatorial Pacific and further investigation may indicate its presence in the western part. It has a counterpart in the Atlantic about which very little is known at this time.

REFERENCES

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2. SVERDRUP, H. U., M. W. JOHNSON, and R. H. FLEMING, "The Oceans." Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1087 pp. Sixth Printing - September 1955.


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